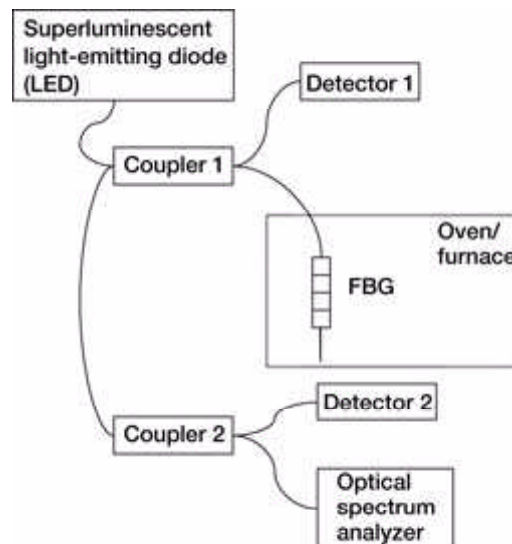


Reannealed Fiber Bragg Gratings Demonstrated High Repeatability in Temperature Measurements

Fiber Bragg gratings (FBGs) are formed by periodic variations of the refractive index of an optical fiber. These periodic variations allow an FBG to act as an embedded optical filter, passing the majority of light propagating through a fiber while reflecting back a narrow band of the incident light. The peak reflected wavelength of the FBG is known as the Bragg wavelength. Since the period and width of the refractive index variation in the fiber determines the wavelengths that are transmitted and reflected by the grating, any force acting on the fiber that alters the physical structure of the grating will change the wavelengths that are transmitted and reflected by it. Both thermal and mechanical forces acting on the grating will alter its physical characteristics, allowing the FBG sensor to detect both the temperature variations and the physical stresses and strains placed upon it. This ability to sense multiple physical forces makes the FBG a versatile sensor.

To assess the feasibility of using Bragg gratings as temperature sensors for propulsion applications, researchers at the NASA Glenn Research Center evaluated the performance of Bragg gratings at elevated temperatures for up to 300 °C. For these purposes, commercially available polyimide-coated high-temperature gratings were used that were annealed by the manufacturer to 300 °C. To assure the most thermally stable gratings at the operating temperatures, we reannealed the gratings to 400 °C at a very slow rate for 12 to 24 hr until their reflected optical powers were stabilized. The reannealed gratings were then subjected to periodic thermal cycling from room temperature to 300 °C, and their peak reflected wavelengths were monitored.

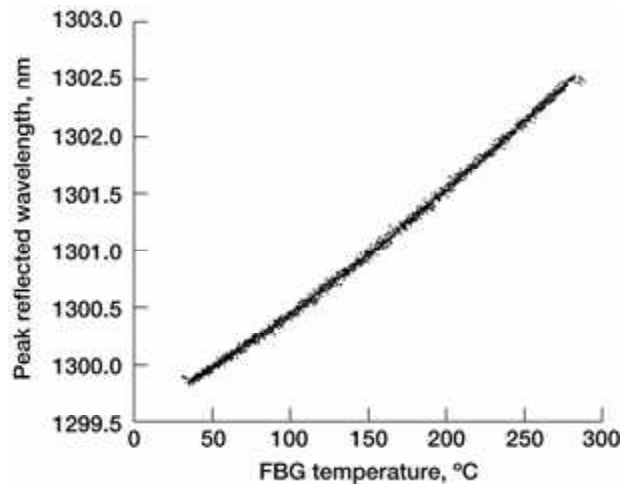


Setup used for reannealing and thermal cycling of FBGs.

The preceding schematic diagram shows the setup used for reannealing and thermal

cycling the FBGs. Signals from the photodetectors and the spectrum analyzer were fed into a computer (not shown in the diagram) equipped with LabVIEW software. The software synchronously monitored the oven/furnace temperature and the optical spectrum analyzer as well as processed the data. Experimental results presented in the following graph show typical wavelength versus temperature dependence of a reannealed FBG through six thermal cycles (80 hr).

The average standard deviation of the temperature-to-wavelength relationship ranged from 1.86 to 2.92 °C over the six thermal cycles each grating was subjected to. This is an error of less than 1.0 percent of full scale throughout the entire evaluation temperature range from ambient to 300 °C.



Experimentally obtained typical wavelength versus temperature dependency of a reannealed FBG through six thermal cycles from room temperature to 300 °C.

Bibliography

Adamovsky, G.; and Juergens, J.: Performance Evaluation of Fiber Bragg Gratings at Elevated Temperatures. SPIE 5272A, Proceedings of the Fiber Optic Sensor Technology and Applications II Conference, 2003.

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